

**Case Study Article**

## A Comparative Study of Three Urban Water Supply Networks as City Landscape Infrastructures

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**Abstract** | Water, as the most vital human need and a life-giving element, has been the first concern in creating any permanent or temporary settlement. The water supply networks in the cities have also been the first urban facilities that have provided a suitable context for humans to live in and played an infrastructure role for cities on a large scale. However, throughout history, their presence in the city has not been limited to a mechanical facility. The reason is that they are a mixture of objective and subjective issues which has turned them into an element of the urban landscape. In this framework, a comparative study of water supply networks in the cities of Semnan in Iran, Bukhara in Uzbekistan, and Fez in Morocco was made as landscape infrastructures. Landscape infrastructure in the city is a city infrastructure that, in addition to serving as a mechanical and functional facility in the city, is a part of the citizens' image and mentality of the city in the context of nature, which plays the role of a major landscape element on a large scale and with the acting of various components. The comparative study of the three mentioned cities shows that although the idea of a water system is proposed as a landscape infrastructure for those cities, the geographical and functional factors in the city have made differences in some three dimensions of the landscape. The factors have brought changes to the formation of their components and elements, which have also had different effects on each city landscape. The water storage pools in Semnan, the geometric ponds of Bukhara in a cultural service complex, and the numerous water springs in Fez are part of the differences that can be seen in each of these networks caused by the functional requirements and the type of water use affected by the geography and climate of the city. Despite these differences in both functional and aesthetic dimensions, the cultural affinity between these cities has brought the identity dimension of these infrastructures closer together.

**Keywords** | *Persian City Water System, Landscape Infrastructure, Landscape Dimensions, Urban Landscape, Comparative Study.*

**Introduction** | Urban infrastructures are essential elements in the formation of the city, which, due to their large scale and impact on the city, can become the main elements of the city landscape. These elements carry an important burden in shaping the city landscape, which is both a tangible body of the city and a mental representation of it, and knowing them can be a tool to strengthen the authentic landscape of the city. Because these elements are loaded on them according to the characteristics of the perspective and according to the passage of time and their inherent talents, they become the infrastructure of landscapes in cities, and dealing with them is dealing with the main roots of the urban landscape. With what potential features do these infrastructures accept this attribute and how do they function in the city landscape after that? Are water networks with the characteristics of

a landscape infrastructure in all cities formed in the same way and play a landscape role? In addition to explaining the characteristics of water networks as landscape infrastructure by comparing three different examples of them, the purpose of this article is to express how they work and their similarities and differences, so that in this way it can reach different angles of a landscape infrastructure.

### Theoretical Foundations

"Today, infrastructure is defined as a set of systems, and activities that shape modern societies and economies, and it is usually used to call any important human-made resource and network on a large scale" (Williams, 2012). In other words, the functional bases and principles of the urban system are based on a foundation that, in the continuation of its growth and development in the city, embodies an image and aspect of the city that will be an important part

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of the city's landscape. These infrastructures, which create the landscape of the city over time, contain information and functions and carry meanings and concepts that raise them as landscape infrastructure; With the same characteristics that a landscape element has in the city and with the same characteristics that are mentioned for a landscape, that is, an objective-mental, dynamic and relative phenomenon that is the result of human interaction with the environment and society with history. "Landscape infrastructure is the natural infrastructure within the city that connects with the life of the city and citizens with the approach of landscapers in different directions and fulfills three goals (functional, aesthetic, and identity) of the landscape at the same time. In fact, an important part of the quality of the city scenery depends on the consistency and durability of this infrastructure in the city and its structure." (Mansouri, Alehashemi & Jamshidian, 2015).

## Samples

Although with the evolution of the concept proposed in landscape studies, many infrastructures in different cities can be defined and explained as landscape infrastructure, the background of the studies conducted in this field is currently limited to a few examples of water networks in cities that fortunately have a good variety. This diversity, the reasons and factors of which will be mentioned below, can bring the study closer to its goals. On the other hand, the water network in these three samples has been studied as landscape elements, which will add to the richness of this analysis.

### • Semnan

The city of Semnan is one of the cities on the edge of the desert of the Central Plateau of Iran, which is formed in the lower reaches of the Gol Rudbar River. This river flows on the ground in a place that is known today as Para or sprinkler due to the presence of water extraction and distribution facilities and moves towards the city by the water network facilities. "Dr. Javad Safinejad believes that the irrigation system of the city (Semnan) in the form of a pool and taking turns using the cisterns has been common in Semnan at least since the 4th century AH, but from the second half of the 7th century onwards, an account and book for the distribution of water in Semnan has been created" (Baniasadi & Tahaie, 1995, 9). The first part of this network is to divide the water into six main streams that supply drinking water to the city. "Para facilities are located on a slope and therefore the water is forced into the first pond. Here, which is the end zone of the free passage of the river, six pieces of wood in the form of wide timbers are laid across the river in levels that become larger downwards. The last barjam, which is the largest and most accurate and is named after the

Great Barjam in the registration file, is eight and a half meters long and facilitates the movement of water and its fall from the barjam to the streams of the allocated areas to be uniform, the surface of the barjam is hammered with iron. This equal level for the sixth barjam has been set so precisely that if some straw is spilled on the bed of the first barjam, it will flow completely evenly along with the water from the great barjam" (Jamshidian, 2011). The main streams and branches form the sub-streams of the main and sub-passages of the city and by delivering water to different parts of each neighborhood, they reach the pools for storing agricultural water (Fig. 1). These pools are the third part of this water network, in addition to keeping water for agriculture, also perform functions such as defining neighborhood centers and supplying water for purposes such as washing. The final part of this water network is the facilities related to the extraction of stored water and its controlled distribution among agricultural lands. By delivering water to agricultural lands, which is calculated after storage and separation, the life-giving task of this water system ends between farmers. Although the primary role of this network has been to deliver water to the city and its citizens, which makes it a respected, maintained, and sometimes sacred element of the city, its other functional roles also reveal other aspects of it. For example, the centrality of the neighborhood around the water storage pools has made them a kind of "The division of localities is mostly based on the use of pools that divide the localities into drinking water" (Baghe Andisheh Consulting Engineers, 2009, 71). of behavioral camp that was part of the collective life of the citizens of the city neighborhoods. The position of this network in the social and popular interactions of citizens is not limited to this point of the water structure and includes all kinds of specialized interactions, such as what farmers have had regarding the distribution of water between lands, to the presence in the popular culture of the people. "Farmers or irrigators of every pool announce their readiness to get water tomorrow..." (Safinejad, 1980). All the people of the neighborhood, clans, and families had a role in the discussion of water maintenance and water infrastructure components. This public participation, which provided the basis for collective activities related to water, was the basis for the formation and continuation of the mental connection of all citizens with water and water infrastructure (Al Hashemi, 2020). In addition to this tangible and visible presence of this water network in the heart of the citizen society, the subjective and more abstract dimensions can also be studied. Dimensions that can be searched for its effects and influence in rituals, customs, literature, arts, and other cultural manifestations of this society. One of the proverbs in which the traces of the components of this system can be found in the

expression used about the tired people: "Teh staleh bete, mo baghchewan (When you fill your pool, send water to my garden as well.)" (Sotoodeh qtd. as cited in Jamshidian, 2011). This way of the presence of the water network shows the mentality of the citizens and the effect it has had on the thinking of the shapers of the city. In traditional news reporting, the head of the pool has also played a role. When they wanted to gather people (especially farmers) in one place, they ordered not to open the head or top of the pool. At the same time, the pool attendant of each pool was instructed to: "Kele noveja" (don't lift the head). And when the water owners and farmers observed that the water was not flowing in the streams, they moved towards the pools and became aware of the situation" (Ahmad Panahi Semnani, 1995, 310).

#### • Bukhara

The geographical location of the city of Bukhara in the south of the Sogd River has required that the high-quality water of this river provides the main life of the city. According to historical sources, this river is controlled by a dam before the city's Kalabad gate and then enters the city. "In Rabz and Bukhara Bazar, the Sogd River splits into two branches, and there is the end of the Sogd River... and what remains of Fazel falls in the drainage basin, equal to near Farber, which is known as Sam Khavash" (Istakhri, 1994, 329). The water system of Bukhara city is also branched from the water outlet of this river and there are 12 streams and rivers scattered in the city that reach ponds of different dimensions which have been located in specific and calculated points. Naturally, the main role of this network has been to bring the source of life to all parts

of the city to solve various water needs for the citizens (Fig. 2). But the turning point of this network, apart from the water streams, can be considered the pools and the urban space around them. Although the importance and spatial value around these spaces are different at different levels, the same role and centrality for these ponds show the privileged mental position of the citizens of these places. A sometimes holy place: "On the eastern side of this hill (Tall Sur), on the side of the door, in front of the gate of Kalabad, which goes to Fatehabad, is the shrine of Imam Abu Shoaib Saleh bin Muhammad Saleh Sanjari." On his grave is the place where prayers are answered... and in the north direction of Fathabad is the tomb of Tal Ghazian" (Moeen al-Foghara, 1961, 67). These water points, from forming a small residential neighborhood center to organizing a medium-sized local cultural center and a large-scale religious scientific center that may have operated beyond the city, could create a central space. The placement of schools, religious mosques, tombs, and mystical corners of Bukhara, next to these ponds, has gradually made the mental load on this water system heavier and deeper (Fig. 3). Gradually, this place has been established in the thoughts of citizens and has become a part of the depiction of writers and painters of the city (Fig. 4). This has caused the severe decline of this network during the colonial era and the former Soviet rule, this network continued to live abandoned and in short under the skin of the city, and with the independence of the Soviet Union and the return to the traditional and authentic urban values of these places, it was managed through a measure in the most successful case, they have turned into tourist centers and witnessed a new life at least in some of their elements. "The remaining eight ponds of Bukhara's water network, due to their location and direct connection with important and religious buildings of the city, their form, shape, and harmonious spatial design, and the social space that has been formed around them by re-planning. They have again become important milestones of the urban landscape of Bukhara's old context" (Mansouri, Alehashemi & Jamshidian, 2014). Although the continuation of the water supply structure to the city of Bukhara cannot be considered its main task, the very existence of this network in today's world shows its stability first in the minds of the citizens and then in the bodies.

#### • Fez

The city of Fez, known as the city of a thousand springs, is one of the most important cities in Morocco and is located on the bed of the Sebu River. "The Pearl River emerges in the plain west of the city, about sixty miles distant, from about 60 separate springs. Its gushing water, gliding over the shining sand, is wonderful to behold" (al-Jazna'i qtd. as cited in Alehashemi, 2017). This river,

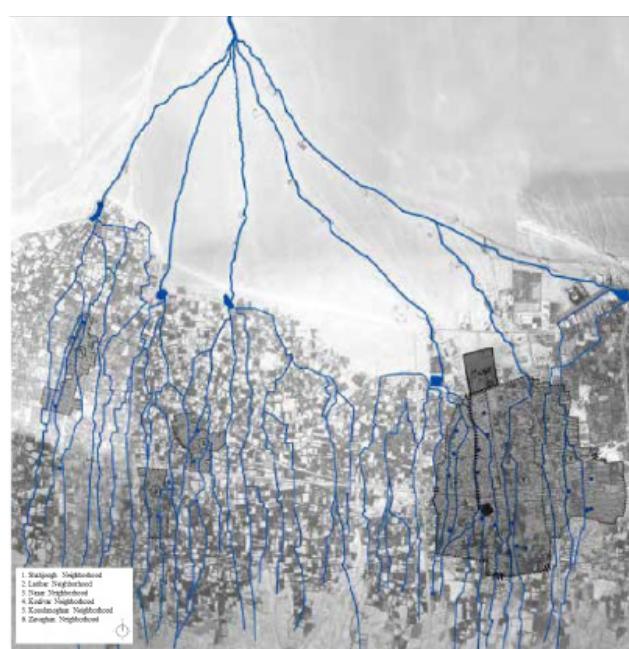


Fig. 1. Adaptation of the main and secondary routes of Semnan city with the movement of water in streams. Sources: Alehashemi, 2020.

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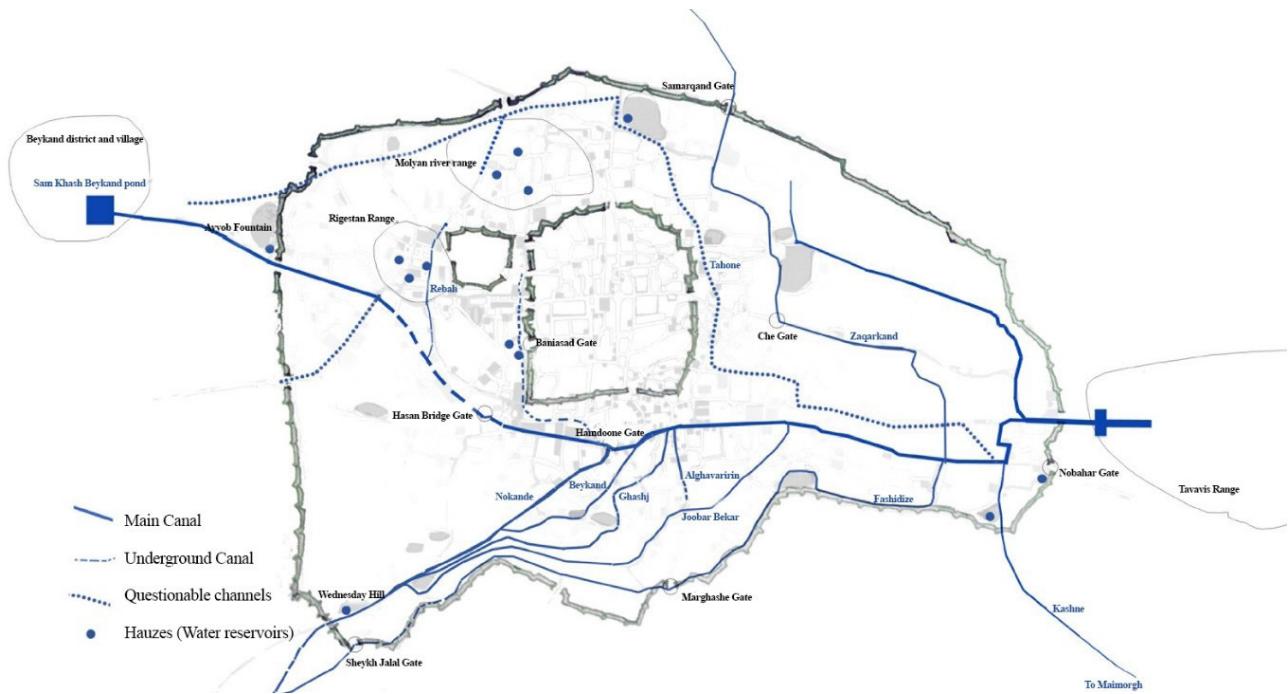


Fig. 2. Bukhara water system map based on historical maps. Source: Mansouri et al., 2015.

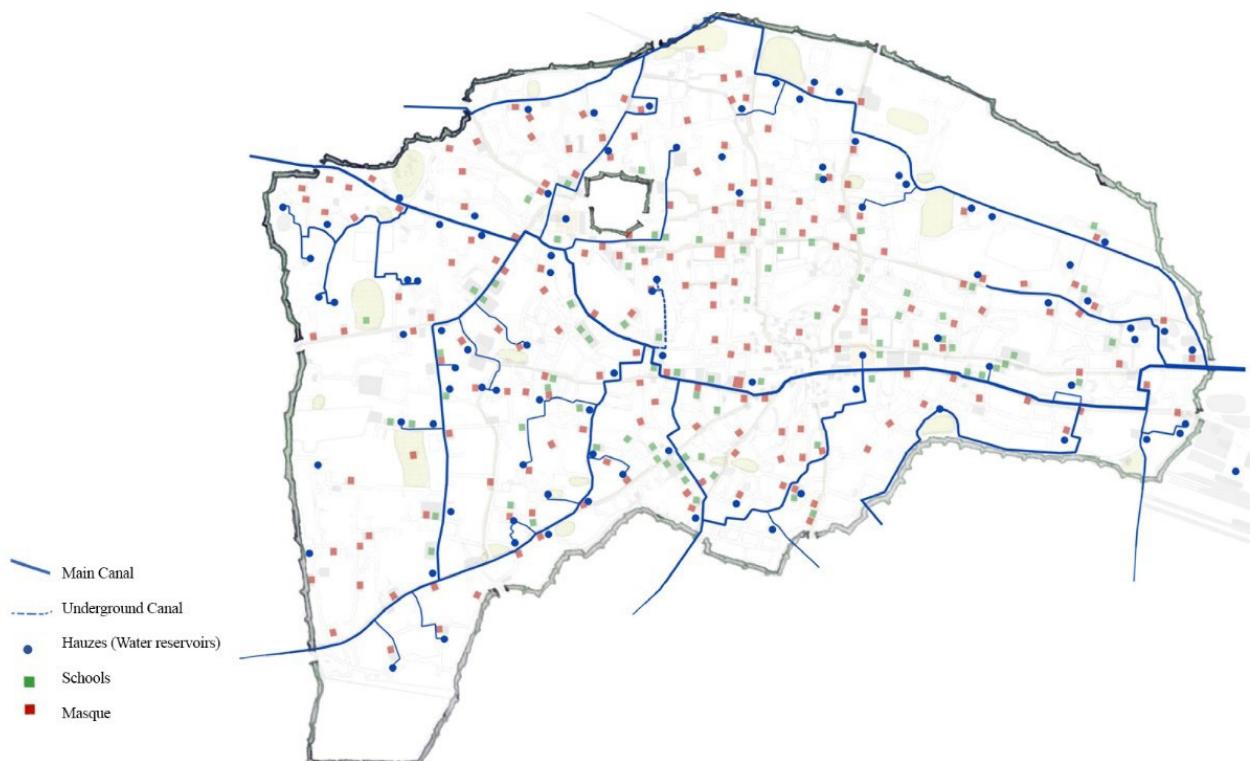


Fig. 3. The distribution map of mosques and schools in the city of Bukhara in connection with the water network of Bukhara, taken from historical maps. Source: Mansouri et al., 2015.

which has shaped the structure of the city around it as a backbone, brings water to all the residents of the city with branches that flow more openly on the ground. Open water streams, in addition to guiding the path of urban passages, have a tangible presence in the city, by creating freshness and improving the quality of space, and are present in most urban landscapes. But what gives

it an identity and a prominent presence is a functional influence in the workshops of leather processing and production of leather products. The traditional method of preparing leather in pools of water and other required materials is one of the main images to introduce the city of Fez to tourists and citizens of other places. An image that shows the scenery of these workshops and consequently



Fig. 4. Wall painting of Ayyub Spring in Bukhara. Photo: Hamidreza Salehi, 2009.

the structure that supplies water to this complex (Fig. 5). “With the connection of the city environment and leather processing industries with the key element of water and the excessive increase in the population, the quality of the river water has been severely affected” (Zandi, 2010). The running water of the river goes through the steps for cleaning the leather and leather tanning and is directed to the city sewer. Another type of presence of water in this city and its connection with other elements of the city, which gives it an identity-making and meaningful face, is its presence in combination with public religious spaces of the city. The last place where water appears in this city is known as spring, under the title “Saqayeh” and “Saqayehs appear in certain places of the city: In front of or adjacent to the entrance gates of the city, in city squares, at the entrance of markets and spatial openings within the market, at the intersection of several paths (spatial openings), in sabbats or neighborhood centers next to mosques, schools, baths, In the same way, they were seen in mosques in the alleys or the courtyards of mosques” (Alehashemi, 2017). By objective reference and historical study of religious places or even small urban nodes, it is possible to understand the position of the smaller parts of this shell in the course of people’s lives since long ago. “The Springs” have affected the center of the neighborhood (Fig. 6). This element has been so important that the builder and the residents have decorated it and distinguished it in different ways. Distinction along with special decorations and details attract the attention of the audience. “Drinking springs” have been in Moroccan cities by establishing and choosing a location in the center of the medinas, and then by providing various services setting the scene for social



Fig. 5. tanneries with traditional work methods are part of the landscape of Fez, which is formed by mixing with the structure of the water network of the city. Source: Author.



Fig. 6. A small drinking spring, as a small neighborhood center.  
Photo: Mohammad Jamshidian, 2015.

gatherings and beautifying the place, etc. as a meaningful and identifying element that has a high capacity (Shojaei, 2017). The fame of the city of Fez as the city of a thousand springs is a manifestation of the reality of the urban landscape of Fez.

## Discussion

The comparison of the three studied cases shows the differences and similarities of these water networks. In the analysis of these three networks as three landscape infrastructures, the basis of this comparative study is their three "functional", "identity" and "aesthetic" dimensions, so that while clarifying how to define them as a landscape element, one can understand the idea of this formation Find out about urban infrastructure. In this analysis, examples are mentioned for each dimension of the landscape in this water network. These examples provide a clear platform for a concrete comparison of these three examples. The discussion about how the landscape infrastructure works in the city has become clearer by stating these examples, and one can have a better understanding of this infrastructure in other cities and other territories. In such a way by matching the

mentioned different dimensions and searching in other cities, it is possible to discover and express their landscape infrastructures. In a general analysis of Table 1, differences and similarities can be pointed out in each of the different dimensions of the study of these water networks as a landscape infrastructure:

- In the functional dimension, apart from providing the vital needs of the city, which is the provision of drinking water and other uses such as washing, and it takes the existence of these networks even before the formation of the city, and as a result, it is common between all three networks, there are differences which can be seen according to the needs of the city and its citizens or the type of economy and their livelihood.
- In the identity dimension, all three networks contain dimensions and conceptual layers of identity. In fact, what has made them a scenic element is having these dimensions parallel to their functional dimensions. Being present in social interactions, spaces that have a ritual and cultural dimension, and becoming an element of identity for citizens is what they have in common in this field.
- In the aesthetic dimension, with a slight difference that sometimes exists due to climatic and geographical features such as the shape of the land and sometimes due to functions integrated with the water system, the principle of forming urban forms is linear (passages) and point or area. (Urban centers) and the principle of combination with plants and the urban body that achieves an urban space is the same in all of them.

## Findings

In summarizing the differences and similarities mentioned in the previous section, it can be concluded that although differences and similarities can be seen in all three functional, identity, and aesthetic dimensions, the unique nature of each water network is comparable to other networks in every dimension. For example, the unique nature of the water network of Semnan is in the functional dimension of having an agricultural function. Because the supply of drinking water and the daily needs of citizens is a matter of course. But what seems to be a significant difference in this dimension is the unique nature of the water networks that are formed in Bukhara around shaping cultural spaces and in Fez around supporting and meeting the needs of the leather industry. But this privileged nature is not visible in the identity dimension. All of these water systems have meaningful values for the citizens and the city, in all of them, the constant and examples of its emergence are also the formation of cultural spaces in a general sense, which includes religious, social, and scientific functions. Presence in mental creations such as arts, literature, and popular culture is also something that is caused by these

Table 1. Comparison of different landscape dimensions in the water infrastructure of the three cities of Semnan, Bukhara, and Fez. Source: Author.

Different dimensions of the landscape			City
Aesthetic	Identity	Functional	
<ul style="list-style-type: none"> <li>-Shaping the structure of roads and urban centers</li> <li>-Creating urban landscapes in the combination of water and trees in the place of pools</li> <li>-Creating strong axes with rows of trees on both sides of streams</li> <li>-Touching less water in streams and more in pools</li> </ul>	<ul style="list-style-type: none"> <li>-Creating an independent identity of urban neighborhoods</li> <li>-Shaping cultural rituals and customs</li> <li>-Presence in poetry, literature, and visual arts</li> <li>- Presence in popular culture</li> <li>-A place of social interactions</li> </ul>	<ul style="list-style-type: none"> <li>-Providing drinking water to the city</li> <li>-Provision of other city water uses</li> <li>-Supplying agricultural water to the city</li> <li>-The centrality of the city center</li> </ul>	Semnan
<ul style="list-style-type: none"> <li>-Shaping the structure of roads and urban centers</li> <li>-Creating urban landscapes in the combination of water, architecture and vegetation in the place of ponds</li> <li>-Touching water in streams and ponds</li> </ul>	<ul style="list-style-type: none"> <li>-Creating an independent identity of cultural centers</li> <li>-The place of formation of memories and historical narratives</li> <li>-Place of social interactions</li> <li>-Tourist attraction (new function)</li> </ul>	<ul style="list-style-type: none"> <li>-Providing drinking water to the city</li> <li>-Provision of other city water uses</li> <li>-The centrality of the city center</li> <li>-The centrality of cultural-scientific-religious centers</li> </ul>	Bukhara
<ul style="list-style-type: none"> <li>-Shaping the structure of roads and urban centers</li> <li>-Creating urban landscapes in the combination of water, architecture, and vegetation in the place of mosques and urban schools</li> <li>-Continuous presence of water in roads and urban centers</li> </ul>	<ul style="list-style-type: none"> <li>-Creating a city identity by being next to the leather industry</li> <li>-Place of social interactions</li> <li>-Shaping religious and cultural identity</li> </ul>	<ul style="list-style-type: none"> <li>-Providing drinking water to the city</li> <li>-Provision of other city water uses</li> <li>-Water supply for the leather industry in the city</li> <li>-The centrality of the city center</li> <li>-The centrality of religious and cultural centers</li> </ul>	Faz

spiritual values, which were not formed in any of the case studies in an alien space with others. In the aesthetic aspect, almost the same principle prevails, because water itself, as a beautiful and beautifying element, is the main component of this urban infrastructure and is the main factor in creating the aesthetic nature of these networks. The only issue that has led to significant differences in this dimension has been the climatic and geographical differences between these cities, which has made the presence of water and its touch different in the role that was mentioned. The hot and dry climate of Semnan has allowed them to appear on the surface of the earth to prevent further evaporation, but in contrast to the more moderate climate of the other two cities, it allows them to appear on the surface of the earth and open air. The more mountainous topography of the city of Fez leads to

a more enthusiastic and noisy presence of water in the city, but the movement and presence of water in the city of Bukhara are more gentle and calm, which both show two different types of beautiful urban landscape (Table 2).

## Conclusion

The findings of this comparative study show that the water networks in the three cities of Semnan, Bukhara, and Fez are scenic infrastructures in terms of the whole and the idea that makes them a "scenic" infrastructure, such as having all three functional and identity dimensions. and they are similar to each other aesthetically; their difference in playing the role of their landscapes comes from the context in which they are located. The context of the urban economy has caused a difference in their unique functional nature, which has provided one in the

Table 2: The similarities and differences of the landscapes of three water networks in the cities of Semnan, Bukhara, and Fez. Source: Author.

Comparative Comparison \ Landscape Dimensions	functional	Identity	Aesthetic
differences	Specific performance appropriate to the economic nature of the city	-	The type and presence of water due to climatic and geographical differences
similarities	Provision of drinking water and daily consumption of citizens	It has a meaning that appears in similar contexts due to cultural affinity	Giving shape to the main structure of the city, creating urban spaces based on water

service of agriculture, another in the service of the cultural space, and the third in the production industry of the city. The geographical and climatic background of each city has also led to differences in aesthetic dimensions. However, the cultural background of these cities due to their cultural proximity and common origins has not only imposed much difference on this infrastructure but has also created spaces with a completely identical cultural

nature, which includes the combination of a water network with a cultural architecture that is sometimes covered with vegetation. As a result, it can be said that the water networks studied in this article as a landscape infrastructure have a common idea or concept that is different in components and elements due to being placed on different platforms.

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